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Resonant X-ray Emission Spectroscopy Measurements of Co-Containing Catalysts

Shelly D. Kelly[1], Simon R. Bare[2], and Gerald T. Seidler[3]

[1]EXAFS Analysis, Bolingbrook, IL 60440, USA
[2]UOP LLC a Honeywell Company, Des Plaines, IL 60016, USA
[3]University of Washington, Seattle, WA 98195, USA

Cobalt-molybdenum catalysts designed for the selective hydrotreating of fluid catalytic cracked (FCC) gasoline produce ultra-low sulfur gasoline by removing sulfur while minimizing octane loss and olefin saturation. Nonselective FCC gasoline hydrotreaters used in the past to remove sulfur also saturate olefins, thus creating paraffins, which have lower octane values. Hence, nonselective FCC gasoline hydrotreaters remove sulfur but also significantly reduce product octane values. Maximizing octane retention adds significant value to the FCC gasoline portion of the motor gasoline pool. Although Co-Mo hydrotreating catalysts have been studied for many years, much remains to be learned about the active catalytic site, and there is demand for better performing hydrotreating catalysts. Indeed, even the active site within this catalyst is still being debated. During the sulfidation of the catalyst, the X-ray absorption near edge structure (XANES) spectra of Co and Mo evolve from the oxide to the sulfided form. Untangling the spectra of the actively changing species from the spectra of the species that do not change (bulk oxide components) is difficult. We have used resonant X-ray emission spectroscopy (XES) to probe Co in these samples in the oxidized and sulfided state to elucidate the Co species that is evolving with activity. Our investigations have determined unique X-ray fluorescence shifts for the active and inactive phases, such that the spectrometer can be used to obtain information about each phase. By comparing samples during different stages of sulfidation and comparing catalysts with different activity, the mechanistic properties can be inferred with the help of many other microscopies and bulk chemistry measurements. A new X-ray spectrometer is uniquely suited to provide the Co XES spectra. We believe there is a wealth of information that many scientific groups could realize by using resonant XES at the Advanced Photon Source.